TECHNOLOGY DEPT.

NOVEMBER 1945
NO. 419 VOL. 49

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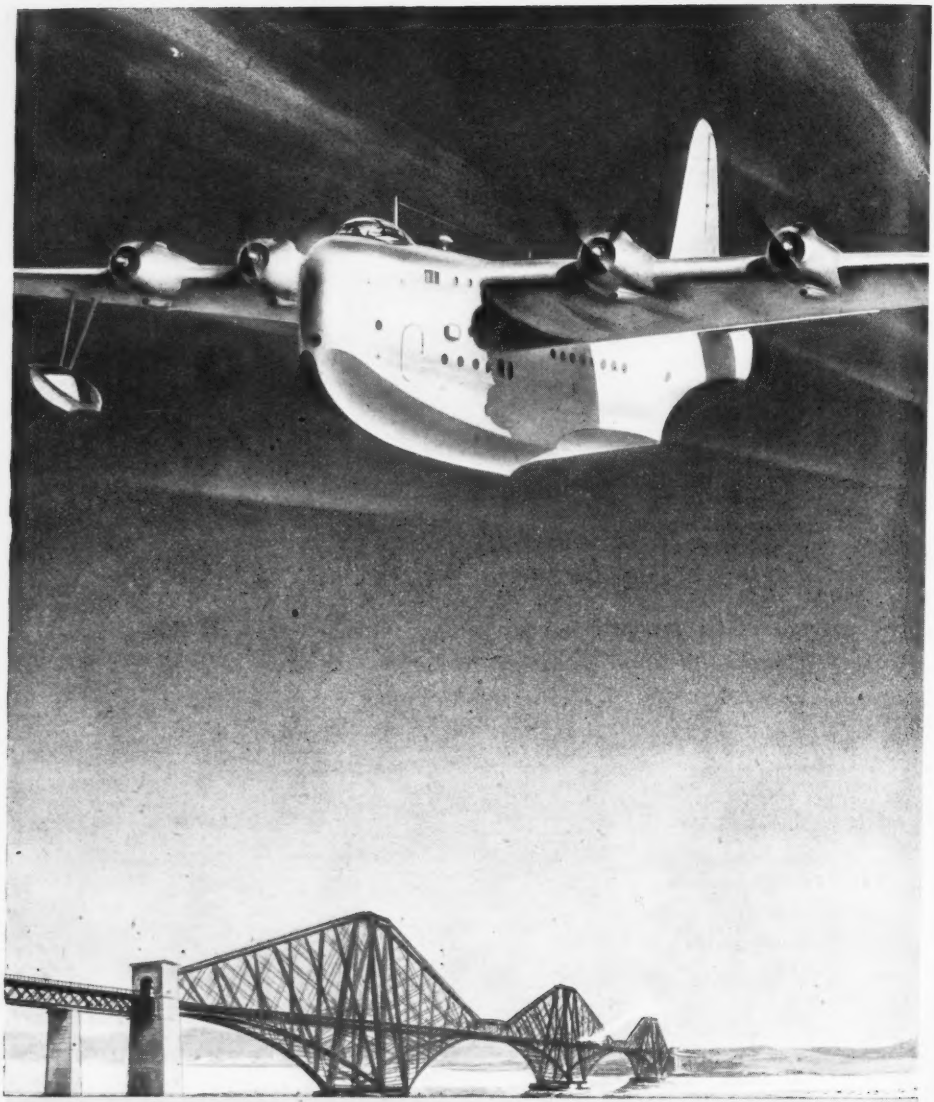

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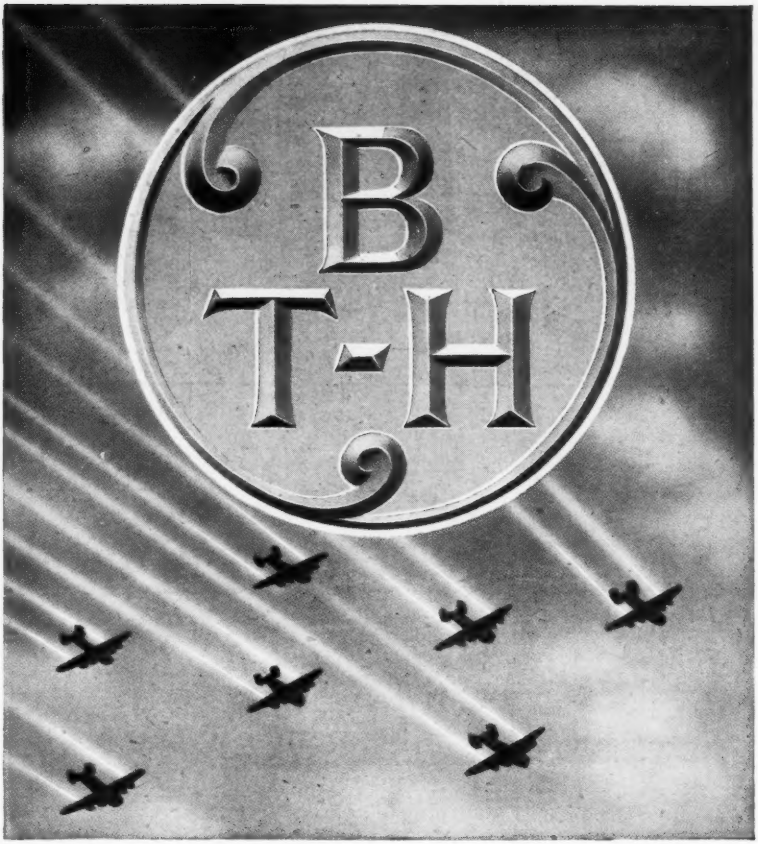

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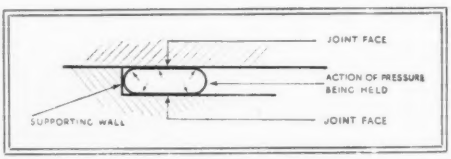

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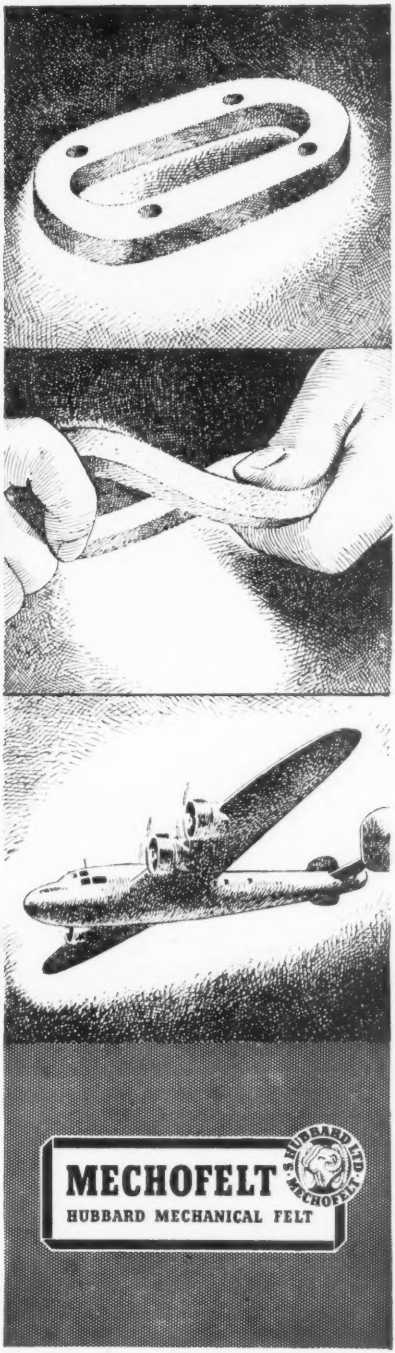

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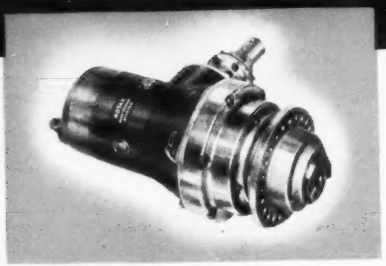

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THE SOCIETY'S AWARDS

The Society offers a number of valuable awards, most of them annually. Full particulars of the conditions attaching to these awards may be obtained on application to the Secretary.

Society's Gold Medal

This is the highest honour which the Society can confer for work of an outstanding or fundamental nature in aeronautics.

British Gold Medal for Aeronautics

The British Gold Medal for Aeronautics is awarded for an achievement leading to advancement in aeronautical science.

Simms Gold Medal

The Simms Gold Medal is awarded annually for the best paper read in any year before the Society on any science allied to aeronautics, e.g., meteorology, wireless telegraphy, instruments.

The George Taylor (of Australia) Gold Medal

The Taylor Gold Medal is awarded annually, at the discretion of the Council, for the most valuable paper submitted or read during the previous session.

Wakefield Gold Medal

The Wakefield Gold Medal is awarded annually to the designer of any invention or apparatus tending towards safety in flying, and is open to members or non-members.

Society's Silver Medal

The Society's Silver Medal is awarded, at the discretion of the Council, for some advance in aeronautical design.

British Silver Medal for Aeronautics

The British Silver Medal for Aeronautics is awarded for an achievement leading to advancement in aeronautical science.

Society's Bronze Medal

The Society's Bronze Medal is awarded, at the discretion of the Council, under the same conditions as those for the Silver Medal, but for some less important advance in aeronautical design.

Wilbur Wright Memorial Premium

The Wilbur Wright Memorial Lecture is held annually, a premium of fifty pounds being awarded to the lecturer invited by the Council to deliver the lecture. The lecture is usually given alternately by an American and an Englishman, and is the most important aeronautical lecture of the year. It is delivered whenever possible, on the last Thursday in May of each year.

British Empire and Commonwealth Lecture

The Council of the Royal Aeronautical Society have completed the arrangements for the founding of a British Empire and Commonwealth Lecture.

The lecture, on any aeronautical subject approved by the Council, will be delivered annually in September in London, by a lecturer, chosen in alternate years from the British Dominions and Colonies and Great Britain.

The Council, by founding this British Empire and Commonwealth Lecture, are anxious to encourage new ideas and new points of view from all parts of the British Empire and Commonwealth, and to make the Lecture second only in importance to the Wilbur Wright Memorial Lecture.

The British Empire and Commonwealth Lecture will have a premium of £50 attached to it, and in the case of lecturers coming from the Dominions and Colonies an allowance up to £100 will be paid towards the Lecturer's expenses.

R.38 Memorial Prize

The R.38 Memorial Prize is offered annually for the best paper received by the Society on some subject of a technical nature in the science of aeronautics, preference being given to papers which relate to airships. The prize is twenty-five guineas.

The Herbert Akroyd Stuart Lectures

Under the will of the late Mr. Herbert Akroyd Stuart a sum of £700 is held in trust by the Society for the offer of a prize every two years, for the best paper or lecture read or given before the Society dealing with the Origin and Development of Heavy-oil Aero Engines. The prize is open to members and non-members.

Edward Busk Memorial Prize

The Edward Busk Memorial Prize is offered annually for the best paper received by the Society on some subject of a technical nature in connection with aeroplanes (including seaplanes). Its value is twenty guineas.

Pilcher Memorial Prize

The Pilcher Memorial Prize is offered annually, at the discretion of the Council, for the best paper by a Student on heavier-than-air craft or any analogous subject. Its value is five guineas.

Usborne Prize

The Usborne Prize is offered annually, at the discretion of the Council, for the best paper by a Student on some subject in connection with Aero Engines. Its value is five guineas.

Major Baden-Powell Memorial Prize

The Major Baden-Powell Memorial Prize is awarded in May and December of each year to the student who is considered the best student by the examiners in the Society's Association Fellowship examinations. Its value is three guineas.

Elliott Memorial Prize

The Elliott Memorial Prize is awarded twice yearly to the apprentice at Halton who has the highest percentage of marks in the passing-out examination. Its value is 2½ guineas for each award.

R. P. Alston Memorial Prize

The R. P. Alston Memorial Prize is awarded to any Graduate or Student of the Society for work done leading to improvement in the safety of aircraft, and particularly for improvement in stability and control. Its value is approximately £5.

Branch Prize

The Council offer an annual prize of twenty guineas for the best paper read before the Branches during the previous lecture Session. The prize is open to any member of the Society or of any Branch.

Journal Premium Awards

The Council has set aside an annual sum of £250 to be given as premium awards to authors of papers published in the Journal.

AN APPRECIATION

The Council of the Royal Aeronautical Society wish to thank those Companies who, by their generous co-operation, have done so much to help in the production of the Journal in its new form.

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THE JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY

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The Journal of The Royal Aeronautical Society was founded in 1897 in succession to the Annual Reports. For the opinions expressed in Papers that are signed or initialled the authors alone are responsible. None of the papers or paragraphs must be taken as expressing the opinion of the Council of The Royal Aeronautical Society unless such is definitely stated to be the case. **The Journal is published monthly at the Offices of the Society, 4, Hamilton Place, Piccadilly, London, W.1.** Subscriptions per annum, £4 13 0 including postage; Single Numbers 7/6 or 7.9 post free. All communications for publication in the Journal, or on general matters affecting the Society should be addressed to — The Secretary, J. Laurence Pritchard, 4, Hamilton Place, W.1. The Society's Bankers are Messrs. Coutts and Co. All communications respecting Advertisement matters should be addressed to—The Advertisement Manager, Journal of The Royal Aeronautical Society, 4, Hamilton Place, W.1.
Telephone: Grosvenor 3515-3516-3517. Telegraphic Address: Didaskolas, Audley, London.

NOVEMBER NOTICES 1945

JOURNAL PREMIUM AWARDS

The Council have set aside an annual sum of £250 for the award of premiums for papers published in the *Journal* and the Council hope that members (or non-members) will contribute papers on their own special subjects.

Gold Medal Award

At their meeting held on October 18th, 1945, the Council unanimously awarded Professor Leonard Bairstow the Gold Medal of the Society and recommended that he be elected an Honorary Fellow. The latter recommendation was unanimously confirmed at an Ordinary Meeting of the Society held later in the day.

Professor Leonard Bairstow, C.B.E., F.R.S., D.Sc.(London), Hon.D.Eng. (Liverpool), A.R.C.Sc., F.Inst.Ae.S., was born in Halifax, Yorks, on June 25th, 1880, and entered the Royal College of Science in 1898. From 1901 to 1904 he did experimental research work on explosions of mixtures of coal gas and air. After spending five years at the National Physical Laboratory, Professor Bairstow became head of the engineering department formed by the A.R.C. and the first superintendent of the new department of aerodynamics. From 1917-19 he was at the Air Board and Air Ministry working on new designs of aircraft and aerodynamics, and in 1920 became Professor of Aerodynamics at Imperial College of Science and Technology. In 1923 he was appointed Zaharoff Professor of Aviation, retiring on June 30th, 1945. Professor Bairstow was Chairman of the Council 1922-23, a member of many Council Committees, and the Wilbur Wright Memorial Lecturer in 1919. He was a Vice-President of the Society from 1930 to 1934. He has also been a member of the Aeronautical Research Committee for many years, and has published many Reports and Memoranda, papers in the Society's Journal and is the author of "Applied Aerodynamics."

An Appeal to Members

The Society is very anxious to have as complete a record as possible in its files of the work of its members. Such a record will enable the Society to be of greater use to its members and to know, particularly, those members who can help the Council and its Committees on problems which are under discussion.

It would be appreciated, therefore, if members would bring their records of work and employment up to date; and in future notify headquarters of any change of job or position on a firm. In most cases the records held by the Society do not go beyond the date of election as Fellow, Associate Fellow or Associate, and often, therefore, are some years out of date.

The Council are forming a number of technical committees and are anxious to draw upon the best talent among its members in order that the most authoritative reports may be presented.

Contents of the November Journal

Aircraft Circuit-Breakers, by C. H. Flurscheim, B.A., M.I.E.E., and J. A. Nott, B.Sc.(Eng.) (Hons.), A.M.I.E.E.

List of Members

A List of Members is in active preparation. Will members therefore send in any changes in their addresses and designations? If a member has more than one address an indication should be given of the one to appear in the printed list. If no notification is received it will be assumed that the titles and address on the Journal envelope or Monthly Notices are correct.

Lecture Programme

The following are the forthcoming Lectures of the first half of the 1945-1946 Lecture Session. Members are admitted without tickets, but non-members must obtain tickets through a member.

The Lectures will be held at 6.30 p.m. in the Lecture Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1 (by permission of the Council of the Institution), with the exception of the lecture by Professor Feather.

November 27th—Aspects of German Aeronautical Development, by W. J. Stern, B.Sc.

December 11th—Meteorology and High Altitude Aviation, by Professor Dobson, F.R.S.

December 19th—Atomic Disintegration, by Professor N. Feather, F.R.S.

The lecture will be delivered in the Institution of Civil Engineers, Great George Street, S.W.1, at 6.0 p.m. (Tea 5.30 p.m.)

Branch Lectures

BIRMINGHAM BRANCH

December 3rd—Gas Turbines, by Dr. S. C. Hooker.

Lecture will be held in the Birmingham Chamber of Commerce, 94, New Street, at 7.0 p.m.

BRISTOL BRANCH

November 27th—Some Aspects of Aero-engine Servicing in the Field, by C. F. Abell, Esq., O.B.E., F.R.Ae.S., M.I.A.E., Service Manager, Engine Division, Bristol Aeroplane Co., Ltd.

December 11th—The Handling Squadron of the Empire Central Flying School, by Wing Commander G. V. Fryer, A.F.C., Officer Commanding the Squadron.

Lectures will be held in the Conference Room, Bristol Aeroplane Co., Ltd., Filton House, at 6.30 p.m.

COVENTRY BRANCH

November 22nd—Modern Experimental Work in Aircraft Structures, by Professor A. G. Pugsley, F.R.Ae.S.

Lectures will be held in the Council Staff Canteen, Old Gulson Library, at 7.0 p.m.

DERBY BRANCH

December 3rd—Annual General Meeting will be held in the Rolls-Royce Welfare Hall, Nightingale Road, Derby.

GLASGOW BRANCH

November 15th—Fuel Injection, by Mr. Morris, in the Royal Technical College, George Street, Glasgow, at 7.30 p.m.

December 15th—Annual General Meeting at 3 p.m., Central Hotel, Glasgow.

LUTON BRANCH

November 21st—Rubber Bonding Applications, by Messrs. Reynolds and Buchan (Andre Rubber Co., Ltd.), and Mr. Moore (Silentbloc).

December 15th—The Importance of Power Plant Development, by Air Commodore F. R. Banks, F.R.Ae.S.

Lectures will be held in The George Hotel, at 7.15 p.m.

MEDWAY BRANCH

December 10th—Flying Experiences, by a Flying Boat Pilot of B.O.A.C.

Lecture will be held in the Mathematics School Hall, Rochester, at 6.0 p.m.

BELFAST BRANCH

November 20th—Aircraft Electrical Installations, by G. A. Coombes, A.R.Ae.S.

December 11th—Modern Development in Aircraft Performance, by C. P. T. Lipscombe, WH.Ex., F.R.Ae.S. (Joint Lecture with the Belfast Association of Engineers).

GRADUATE AND STUDENT SECTION

Thursday, November 29th—Large Wooden Aircraft, by J. K. Crowe, A.F.R.Ae.S. (De Havilland Aircraft).

Friday, December 7th—Steel. Film show by courtesy of John Brown & Co., 6.0 p.m. British Council Theatre, 6, Hanover Street, W.1. Refreshments available from 5.30 p.m.

All meetings will be held in the Library of the Society at 4, Hamilton Place, W.1, at 7.30 p.m., unless otherwise stated.

Election of Members

Associate Fellows

Bertram Thomas Bayne, Eugene Brame, David Allen Richard Clark (from Associate), Percy John Duncton (from Student), Frank Denis Frankland (from Student), James Marston Heron, John Charles King, Peter Mitchell (from Graduate), Jack Joseph Molins (from Graduate), Alexander Muraszew, Ronald Riley (from Graduate), Harold Saville, Robert Bruce Scutt, Thomas Simpson, Edgar Vernon Starr, James Teague (from Graduate), Guy Hollingsworth Tidbury, Karl Weinstein, John Victor Price Williams (from Graduate), John Keri Williams (from Graduate).

Companions

Bede Alfred Boyle, Paul Lionel Edwards (from Student), John Robert Provost Henderson, Colin Hamilton Macfie.

Associates

Cyril Geoffrey Marmaduke Alington (ex-Student), Benjamin Beck, Lawrence Henry Berwick, Arthur Rowsell Bishop, Frank Egginton Bott, Richard Harold Botterill (from Student), Jean-Louis Bouet, Fred Bulley, Herbert Kenneth Cartwright, Alfred Edmund Collins, Derek Randal Cuming, Gordon Atherley Earl, Oliver Grantham Falwasser, Arthur Stanley Fearfield, Cecil Augustus Fleming, Roy Gerald Ford, Frank John French (from Student), Lucius John Fry, Ralph William Furness, Douglas Garnett, Dennis William Patrick Grey, John Percy Gumbley, Arthur William George Hersee (from Student), Sydney Wright Hill, Andrew Hamilton Horn, Glyn John, Roy John Jennings, William James Hemmings, Joseph Reginald Cyril Lane, Nathan Levitan, Patrick Rolland MacIver, Kenneth Vernon Mason, Alan Stewart McCracken, Lionel Victor Hugo McKechnie, Walter McLoughlin, David Basil Gerald Miles (from Student), Edward Milne, Brian Hugh Moloney, Edward Mucha, Francis Murphy, Anthony Alexander Thompson - Murray, William Musson, Harold James Nightingale, Gordon Percy Olley, Joseph Harold Orrell, John Robert George Pearce, Ernest Peck, George Leslie Proctor Phillips, Herbert Reeves, Joseph Mortlock Scruby, Edwin Joseph Spencer, Grace Delap Stevenson, Alfred Jordan Stockwell, Louis Gustave Trichardt, William Henry Wanley, John Watt, David Alan Webb, Harry Sydney White, William Arthur Wildman, Edward Stanley Willey, Wilfred Harry Yates.

Graduates

Guy Birch Brushfield (from Student), Jorge Carnicero, Arthur Conway (from Student), John Dubbury (from Student), Alan Fielden, John Peter Fullam, Frank Galloway, Joseph Graham, John Hamer Hunt, Arthur P. Kennedy (from Student), Frank Madden, Kenneth George Gray McGregor, Philip William Pilkington, Norman Francis Searle, Roy Spence, John James Spillman (from Student), Harry Tyler (from Student), Raymond Archibald Watts, Ronald Bruce Wyke (from Student).

Students

David Herbert Allon, Kenneth George Allport, Frederick Neilson, Rex Ballam,

Aubrey Charles Ericson, James Arthur Estop, Daniel Clifford Evans, John Goldfinch, John Gilmour Henderson, William Aubrey Hughes, David Ivan Hunt, Douglas David Jones, Peter Lightfoot, Eric Hamilton Lloyd, David Charles Lambert Lovell, Barry Alaric Gault MacGowan, Cecil James Olaf Moorhouse, Alan Vernon Moxom, Albert Edward Osmotherby, Peter Rowland Payne, B. Ramakrishna, Peter Silk, William Ernest Summerhayes, William Tingle, Philip Francis Winter, Norman Aubrey Woodwell, John Keith Yates.

Additions to the Library

Pamphlets in italics with location reference following in brackets. Books marked * or ** may not be taken out on loan.

BB.c.102—Airscrews. M. A. S. Riach. Crosby, Lockwood & Son, 1916. (2nd copy.)

BB.f.60—*Instructions for dismantling, overhauling, repairing, calibrating, testing and installing the KBB-Kollsman Airspeed Indicator Mark IXD, IXE, IXF. Kelvin, Bottomley and Baird, Ltd.* 1945. (File Case.)

C.d.151—The Airship. Christopher Sprigg. Sampson Low. (c.1930.)

D.b.241—Bridging the Atlantic: a chronological record of all projected, attempted and successful Atlantic flights, etc. Francis J. Field. 1945. 10/-.

D.b.242—The Air Mails of the British Isles. H. Stanley Redgrove. Francis J. Field. 1940. 16/-.

E.b.112—*Northampton Polytechnic. Part-time (Day and Evening) Courses in Engineering.* 1945. (PE.2.b.)

E.d.26—Engineering Inspection. A. C. Parkinson. Pitman & Sons. 1944. 6/-.

E.h.7—Aircraft Production Illustration. George Tharratt. McGraw-Hill, 1944. 21/-.

EE.h.14—Jet-propelled Aircraft. Real Photographs Co., Ltd. 1945. 3/-.

G.e.G.26—*Swelling stresses in gels. Forest Products Research Report No.* 6. *H.M. Stationery Office.* 1945. 1/-. (PG.8/8.)

I.a.38—Introduction to Aircraft Performance Calculations. P. H. Sumner. Crosby, Lockwood & Son. 1945. 7/6.

J.g.213—*Correlations of solar variations with Washington weather. Smithsonian Miscellaneous Collections, Vol.* 104, *No.* 13. *Smithsonian Institution, July* 28*th,* 1945. (Y.30.1.)

L.a.53—Allan's Guide to the Pilot's "A" Licence. W. J. D. Allan. George Allen & Unwin. 1945. 7/6.

M.a.29—Cathode Ray Oscillographs. J. H. Reyner. Pitman & Sons, 1945. 6/-.

M.c.69—Aviatsionnoe Radio. (In Russian.) Moscow. 1943.

J. Laurence Pritchard,
Secretary.

AIRCRAFT CIRCUIT-BREAKERS

by

C. H. Flurscheim, B.A., M.I.E.E.,

and

J. A. Nott, B.Sc.Eng. (Hons.), A.M.I.E.E.

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Mr. Nott joined Metropolitan Vickers in 1932, and obtained an Honours Degree in Engineering in 1936. He is a switchgear engineer.

1. GROWTH OF AIRCRAFT ELECTRIFICATION.

The electrical power demand in aircraft has shown a very marked increase in recent years consequent on the development of many new airborne electrical devices in the field of armaments, communications and the control of flight. Whereas not many years back the total demand on the largest aircraft could be supplied from a small windmill driven generator of fractional kilowatt output, designs are now in existence requiring 24 kW. generating capacity, while larger loads are projected for future types.

The power distribution problem has therefore been widely modified and the increased importance of the electrical services performed has considerably raised the status of a one-time Cinderella. This growth is analogous to that which has occurred in other classes of power supply, such as power stations and ships in which the circuit-breaker has widely displaced the switch-fuse unit. Whereas with the small powers originally employed and the relatively unimportant circuits operated, switches and contactors with or without fuse protection were considered sufficient, modern aircraft have opened up the field for circuit-breaker distribution affording built-in automatic protection. As aircraft extend in size it is to be expected that circuit-breakers with separate relay protection will become both practical and advisable on the more important circuits.

2. THE NEED FOR AIRCRAFT CIRCUIT-BREAKERS.

The advantages afforded by circuit-breakers replacing switches and fuses may be briefly summarized with reference to the conditions under which protection is required in airframes.

(*a*) *Overloads on Power-Driven Devices.*

Overload on motors with consequent overcurrent may be caused by excessive friction in the mechanisms operated as the result of a variety of troubles. It is liable to occur in aircraft on account of the flexibility of the whole structure under varying aerodynamic stresses, icing on exposed surfaces such as undercarriage doors, or freezing-up of drives by changes in humidity and ambient temperature. In addition, jamming may result from mud thrown up during take-off or as the result of enemy action. All the above may produce temporary or permanent overload conditions but these are often of such a type that the mechanisms are capable of operation by repeated attempts, provided that the drive is not burnt out through excessively long operation in the first attempt.

Other forms of overload may be imposed by incorrect operation of ancillary equipment such as limit switches, resulting in failure to cut off the supply at the completion of movement; by unduly high accelerations of the airframe during the operation of components of large inertia such as undercarriage; or by operation of flaps or dive brakes while flying at air speeds above those permitted for their use.

(*b*) *Excessive use of Short-rated Gear.*

A number of the drives in airframes belong to a very short time rated class. Undercarriages, for example, which are required in normal flight to be operated only during take-off and landing might be operated by maintenance crews on a rapidly repeated cycle of raising and lowering until the motors are damaged. Similarly, engine starting equipment might be burnt out while cranking cold engines or by prolonged turning over of free engines when clearing petrol laden cylinders.

(*c*) *Failure of Insulation Resulting in Short-Circuit.*

Failure of insulation is a possibility with all electrical equipment and results in short-circuit limited only by the impedance of the circuit. Insulation may be frayed by vibration or reduced in effectiveness by deposits of dirt, salt, or condensation on creepage surfaces, and these effects may be accentuated by reduced pressure at altitude. Short-circuits may also be caused by enemy action.

3. THE ADVANTAGES OF AIRCRAFT CIRCUIT-BREAKERS.

Reference to the above causes of failure will show that the circuit-breaker with built-in protection has advantages as compared with the switch and fuse as below:—

(*a*) *Protection of Short-Rated Gear.*

Engine starters, undercarriages, flap drives, and similar short-rated units under the sole control of the air crew, who initiate operation when required, may be protected against abuse arising from excessive operation without limiting their proper use by disconnecting such apparatus automatically when a dangerous temperature is reached, even with currents not exceeding the normal full load value. Graded protection can be afforded to items which may have varying load currents such as engine starters under cold and warm conditions, or flaps at low and high speeds. Fuse protection is not practicable with this class of service since no overload condition relative to full load current actually exists and such installations have usually been installed without any form of protection. If fuses are employed they are liable to be brought to a crystalline state by overheating and may subsequently blow unnecessarily at a time when replacement may be both awkward and dangerous.

(*b*) *Protection of Apparatus Controlled by Limit Switches.*

Protection can be afforded to apparatus, the operation of which is controlled by limit switches. These are often mounted in exposed positions and the consequences of faulty operation are greatly reduced when the motor can be left in an undamaged state ready for a further operation.

(*c*) *Protection of Continuously Rated Gear.*

Protection can be afforded to continuously operated equipment in the case of prolonged overloads or short-circuit. Complete protection may not always be possible without the use of relays unless the apparatus concerned is more conservatively rated than is sometimes the case in aircraft. It is, however, more comprehensive than that offered by fuses.

(*d*) *Ease of Circuit Restoration.*

Circuit-breakers which have tripped an overload can be reclosed by the pilot or mechanic after the essential period allowed for the cooling of the protected equipments. Vital apparatus such as turrets can, therefore, be restored to service with the minimum of delay after a temporary overload. The replacement of fuses must be a longer operation and may often be impracticable.

(*e*) *Reduction of Weight in Wiring.*

While the weight of a circuit-breaker is sometimes greater than that of the equivalent switch or contactor and fuse, the overall installed weight may be less. This is because the wiring required is reduced by avoiding deviations through fuse boxes which must be placed in accessible positions not necessarily in the direct wiring run.

(*f*) *Saving in Space.*

Circuit-breakers save space by eliminating separate fuse boxes and their associated wiring, a factor of special importance in smaller aircraft such as fighters.

(*g*) *Protection against Short Circuits due to Insulation Failures.*

High speed protection is afforded under short-circuit conditions such as those resulting from cable insulation failure. These faults are sometimes intermittent and the ability to reclose a number of times presents advantages over the repeated replacement of fuses.

Figure 1 shows a number of applications where circuit-breakers could be used to advantage in a modern commercial aeroplane.

3. SPECIAL REQUIREMENTS FOR AIRCRAFT CIRCUIT-BREAKERS.

While the normal requirements in industrial practice apply also to airborne circuit-breakers, a number of special criteria exist peculiar to the aircraft type:—

(*a*) *Reliability.*

Reliability requires especial emphasis in airborne equipment, not that unreliability may be tolerated in industrial equipment, but because it is more difficult to attain. The normal factors of safety and uncertainty which are provided for in industrial equipment and which are usually very large cannot be incorporated in the aircraft type, which must be designed on account of weight to perform its rating with little margin. Consequently all parts are highly loaded electrically and mechanically and it is essential that prolonged testing is carried out to ensure that the margin of safety is sufficient on every one of the components. Parts requiring adjustment during maintenance should also be accessible and not easily distorted.

(*b*) *Weight.*

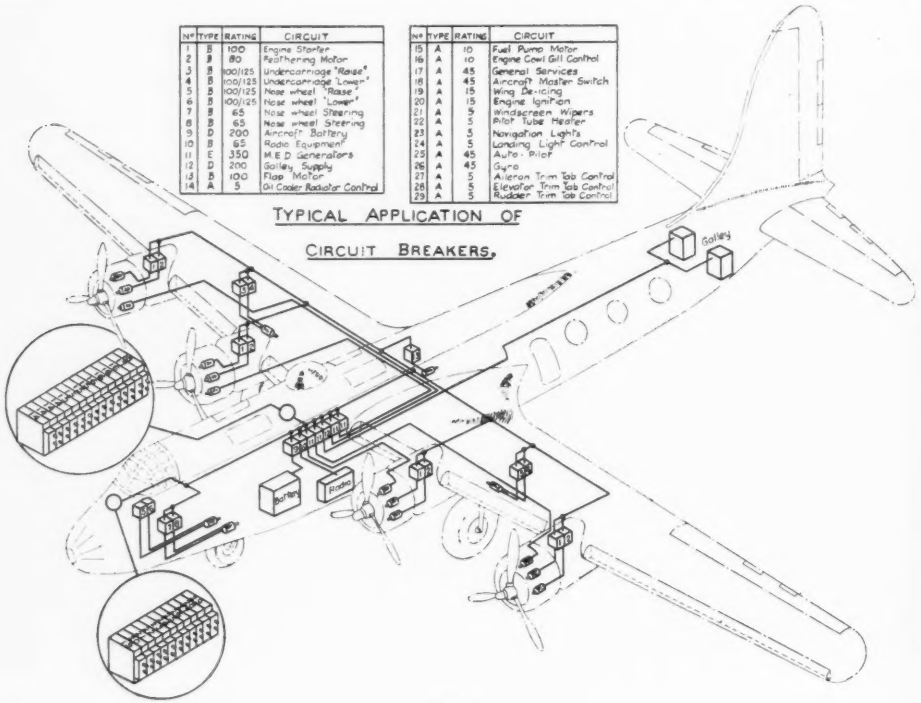
Weight is clearly a vital factor in aircraft components. After allowing for airframe, engines, crew and fuel, the effective displaceable load of an aircraft is very limited. For bombers it is the bomb weight transported to the target and the percentage of the all-up airframe weight actually carried in bombs may vary from 10% to 30% according to the range required. With civil transports the effective payload is the passengers and baggage or cargo, and the percentage this load represents is of the same order since increased safety factors offset savings due to omission of military equipment. An average figure may be that every extra pound weight of effective capacity requires six extra pounds weight of airframe to carry it. The corollary is that an unnecessary one pound weight of electrical equipment will require the machine to be larger by six pounds for the same disposable load.

Manufacturing costs are therefore of secondary importance if weight can be reduced by the use of special materials or additional machining. Normal design practice for land or ship equipment cannot be applied and it becomes necessary to review specifications affecting temperature rise, enclosure and life in the light of their effect on weight.

(*c*) *Dielectric Reliability.*

Insulation materials used must be capable of resisting condensation without undue deterioration in surface breakdown or resistance. High grade bakelite mouldings are effective in this respect provided adequate creepages are allowed. Many 24 volt designs are used in which air gaps and creepages of less than 1/16″ exist. In the authors' experience, little penalty in weight is introduced by tripling these figures, especially as far as creepage inside the circuit-breaker is concerned. Exposed terminal blocks which are

not waterproof should have even larger creepages of the order of $\frac{3}{4}$" if they are to withstand the severe humidity tests now proposed, but this may sometimes require considerable sacrifice in weight. A further important factor in maintaining high insulation levels under damp conditions is to reduce to a minimum the area over which leakage currents can flow. to mount circuit-breakers and similar control items together in large boxes with hinged doors for access, the individual items being unprotected. Such arrangement will reduce weight provided that flame-proofing requirements are waived, as the reinforcing of large boxes to withstand the explosion pressure requires considerable increase in weight.



No	TYPE	RATING	CIRCUIT
1	B	100	Engine Starter
2	B	80	Feathering Motor
3	B	100/125	Undercarriage "Raise"
4	B	100/125	Undercarriage "Lower"
5	B	100/125	Nose wheel "Raise"
6	B	100/125	Nose wheel "Lower"
7	B	65	Nose wheel Steering
8	B	65	Nose wheel Steering
9	D	200	Aircraft Battery
10	B	65	Radio Equipment
11	E	350	M.E.D. Generators
12	D	200	Galley Supply
13	B	100	Flap Motor
14	A	5	Oil Cooler Radiator Control

No	TYPE	RATING	CIRCUIT
15	A	10	Fuel Pump Motor
16	A	10	Engine Cowl Gill Control
17	A	45	General Services
18	A	45	Aircraft Master Switch
19	A	15	Wing De-icing
20	A	15	Engine Ignition
21	A	5	Windscreen Wipers
22	A	5	Pitot Tube Heater
23	A	5	Navigation Lights
24	A	5	Landing Light Control
25	A	45	Auto-Pilot
26	A	45	Gyro
27	A	5	Aileron Trim Tab Control
28	A	5	Elevator Trim Tab Control
29	A	5	Rudder Trim Tab Control

Fig. 1
Protection of Aircraft Electric Installation.

(d) Enclosure.

Enclosure of aircraft circuit-breakers and similar equipment presents a controversial problem. Existing designs have been controlled largely by specifications requiring flame proof and drip proof housings with, more recently, watertight terminal arrangements. Flame-proofing of small circuit-breakers in itself is no design hardship provided it is also necessary to afford complete enclosure for other reasons. It is felt, however, that in some applications it would be desirable

With regard to water-proofing, the authors feel that there is no satisfactory half-measure and that either designs should be of open type, capable of being fitted with dustproof enclosures, or they should be waterproof with glanded cable entry capable of withstanding the differential air pressure of the order of 10 lb./sq. in. which exists between sea level and the maximum altitude for which the equipment would be used. Partial protection which may show itself to be satisfactory under severe humidity tests at one pressure is likely

to fail if these tests are carried out with differential pressure under conditions which may exist after repeated removal of covers and glands for inspection purpose. If a fully pressure-proof unit is offered, the design should be capable of being remade pressure tight repeatedly with little risk of deterioration in performance.

Fully pressure-proof enclosure will seriously increase the weight of circuit-breakers and should therefore be resorted to only when conditions are known to be severe, such as in tropical climates or in exposed positions sometimes adopted in engine or wheel nacelles.

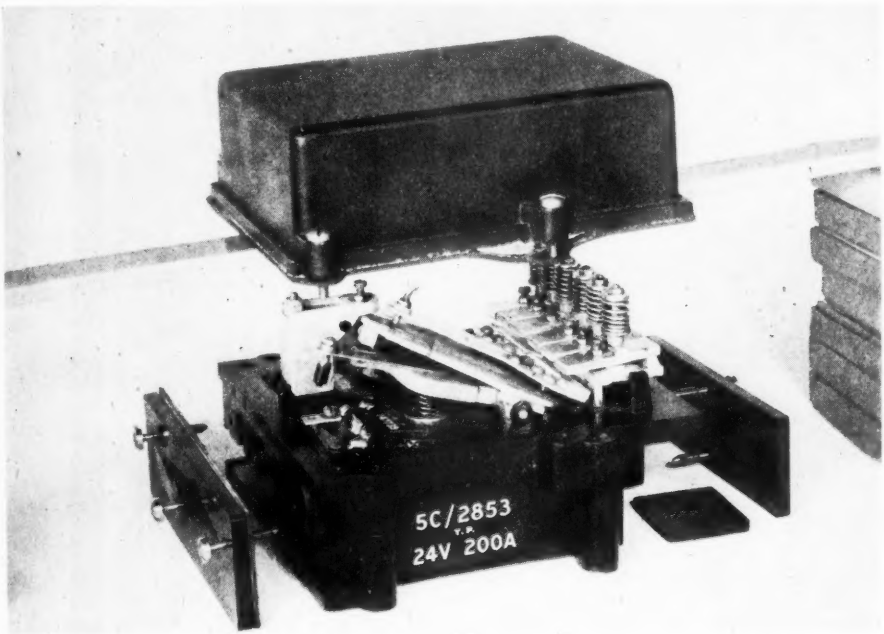


Fig. 2
Photograph of Type D Circuit-Breaker, showing contact arrangement.

4. DESIGN FACTORS.

The following notes refer principally to 24/29 volt D.C. circuit-breakers but apply also in part to 208 volt, 400 cycle A.C. designs.

(*a*) *Conductors.*

The summation of contact voltage drops at hinge points and joints represents a large proportion of the total in a circuit-breaker—apart from that in the thermal element itself. Silver or silver-plated conductors are therefore desirable to prevent oxidation of the contact surface and permit the use of higher current densities and temperatures. The former may reach 6,500 amps/sq. in. for the smaller units, the determining factor in these being not so much the density at any one point but the total watts dissipated within the circuit-breaker.

(*b*) *Arrangement of Contacts for Breaking-Capacity and Life.*

A total break of 0.2″ has proved satisfactory for providing adequate breaking-capacity for 24-volt systems. The effect of altitude up to 40,000 ft. on short circuit or inductive load

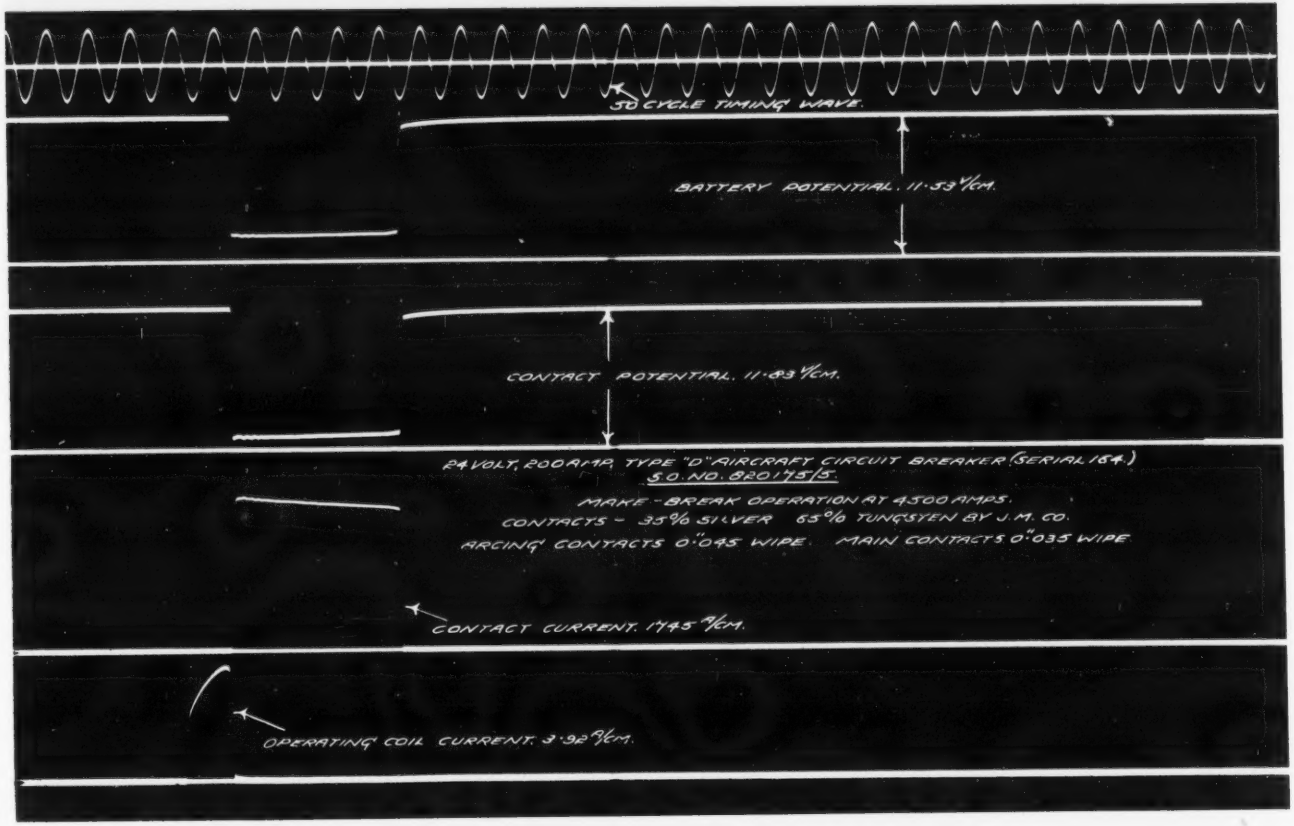

50 CYCLE TIMING WAVE.
BATTERY POTENTIAL. 11·53 V/CM.
CONTACT POTENTIAL. 11·83 V/CM.
24 VOLT, 200 AMP. TYPE "D" AIRCRAFT CIRCUIT BREAKER (SERIAL 184.)
S.O. NO. 820175/S.
MAKE-BREAK OPERATION AT 4500 AMPS.
CONTACTS - 35% SILVER 65% TUNGSTEN BY J.M. CO.
ARCING CONTACTS 0·045 WIRE. MAIN CONTACTS 0·035 WIRE
CONTACT CURRENT. 1745 A/CM.
OPERATING COIL CURRENT. 3·92 A/CM.

Fig. 3 (a)
Oscillographs, showing test series on Type D Circuit-Breaker at 4,500 amps.

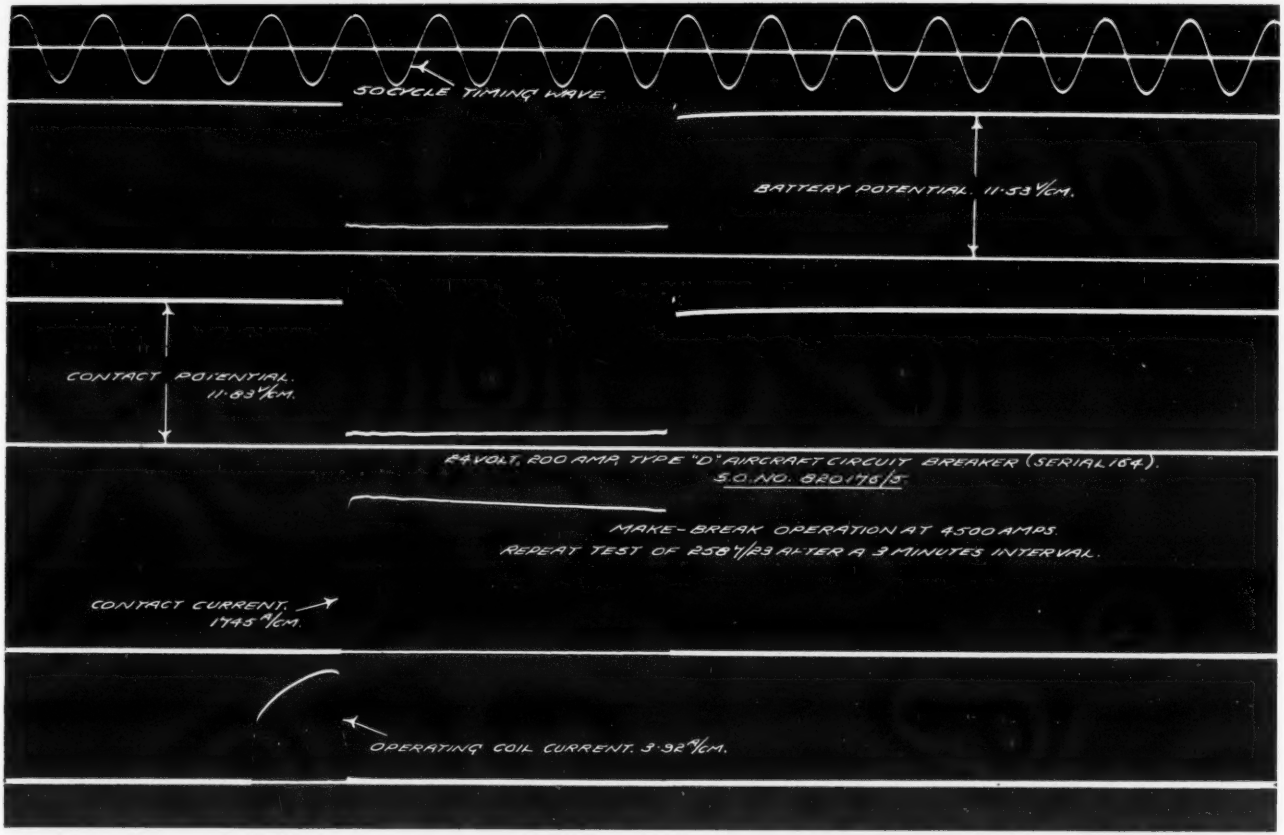

50 CYCLE TIMING WAVE.
BATTERY POTENTIAL. 11·33 V/CM.
CONTACT POTENTIAL. 11·83 V/CM.
24 VOLT, 200 AMP. TYPE "D" AIRCRAFT CIRCUIT BREAKER (SERIAL 164).
S.O. NO. 820176/5.
MAKE-BREAK OPERATION AT 4500 AMPS.
REPEAT TEST OF 258 1/2 3 AFTER A 3 MINUTES INTERVAL.
CONTACT CURRENT. 1745 A/CM.
OPERATING COIL CURRENT. 3·92 A/CM.

Fig. 3 (b)
Oscillographs, showing test series on Type D Circuit-Breaker at 4,500 amps.

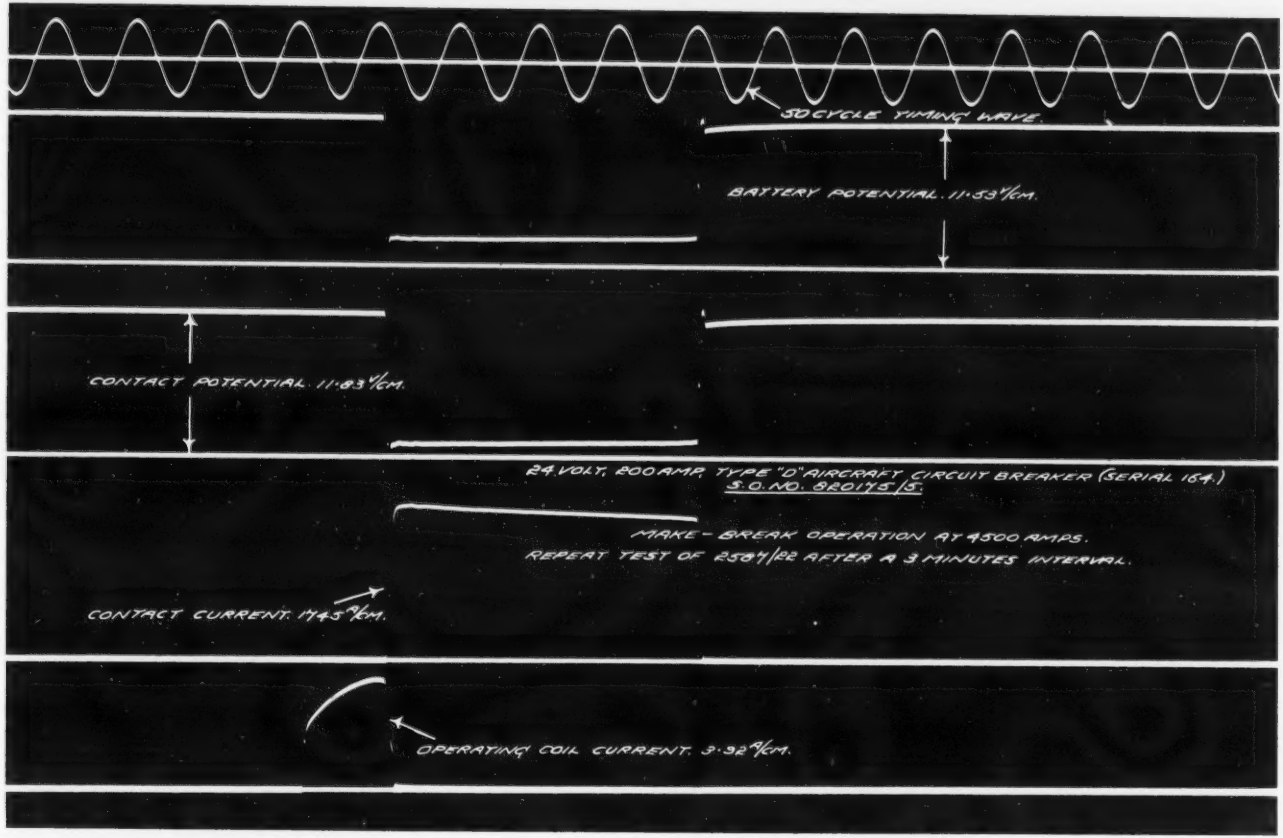

50 CYCLE TIMING WAVE.
BATTERY POTENTIAL. 11·53 V/CM.
CONTACT POTENTIAL. 11·83 V/CM.
24 VOLT, 800 AMP. TYPE "D" AIRCRAFT CIRCUIT BREAKER (SERIAL 164.)
S.O.NO. 820175/S.
MAKE-BREAK OPERATION AT 4500 AMPS.
REPEAT TEST OF 2504/22 AFTER A 3 MINUTES INTERVAL.
CONTACT CURRENT. 1745 A/CM.
OPERATING COIL CURRENT. 3·92 A/CM.

Fig. 3 (c)
Oscillographs, showing test series on Type D Circuit-Breaker at 4,500 amps.

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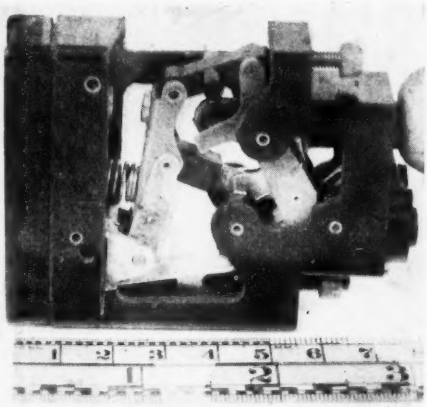
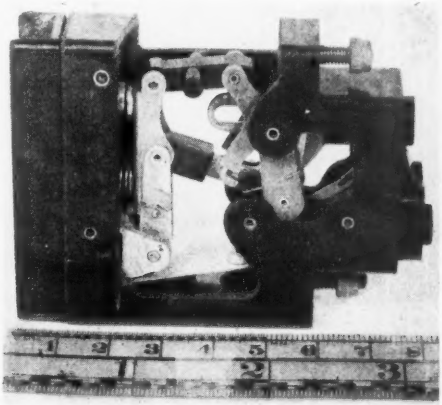
interruption has also been found to be negligible.

Silver or silver tungsten sintered alloys in the contact arrangement must be chosen to provide the most favourable compromise between the conflicting demands for a low voltage drop when carrying normal current and adequate making and breaking-capacity with long life when interrupting normal resistive or inductive currents. It is usually specified that circuit-breakers should be capable of full load operation 10,000 times without maintenance and this is often the limiting criterion in the latter category.

Combinations which have proved successful vary with capacity. For small hand-operated units, adequate life and breaking-capacity are obtained with pure silver contact tips enabling

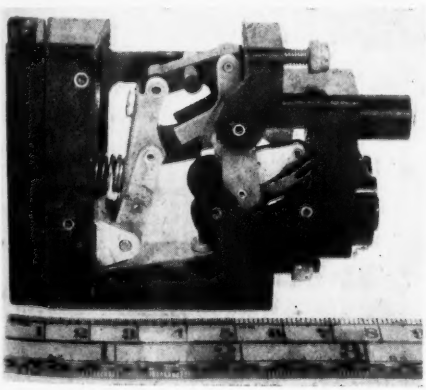


Housing sectioned to show Breaker in open position.



Housing sectioned to show Breaker closed.

Housing sectioned to show Breaker automatically tripped.



Complete Circuit-Breaker

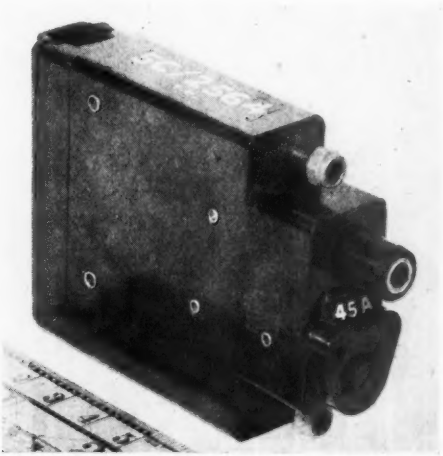


Fig. 4
Photograph of Type A Circuit-Breaker with case cut away to show mechanism.

Oscillographs, showing test series on Type D Circuit-Breaker at 4,500 amps.

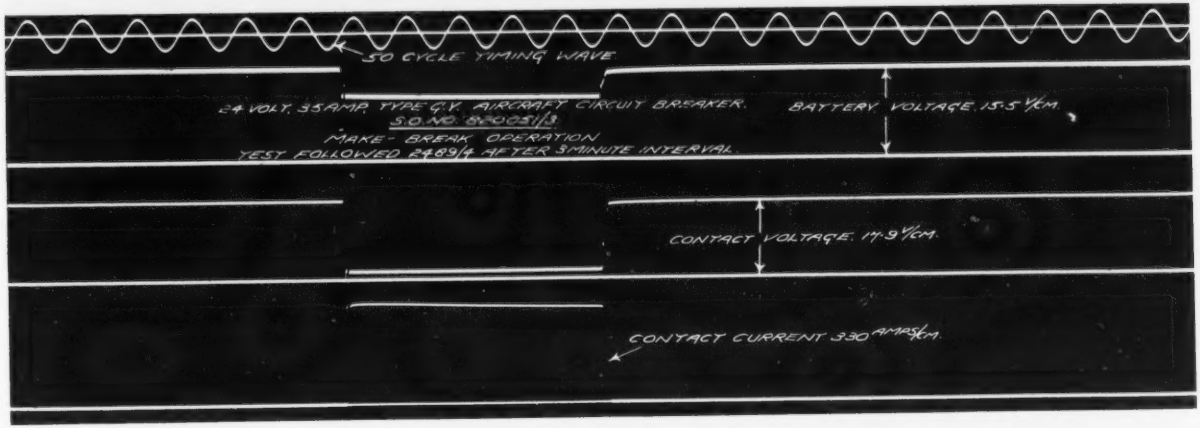

50 CYCLE TIMING WAVE
24 VOLT, 35 AMP. TYPE G.Y. AIRCRAFT CIRCUIT BREAKER.
S.O.NO. B80051/3.
MAKE - BREAK OPERATION
TEST FOLLOWED 24894 AFTER 3 MINUTE INTERVAL.
BATTERY VOLTAGE. 15·5 V/CM.
CONTACT VOLTAGE. 14·9 V/CM.
CONTACT CURRENT 330 AMPS/CM.

Fig. 5 (a)
Oscillogram, showing contact bounce on small circuit-breaker.

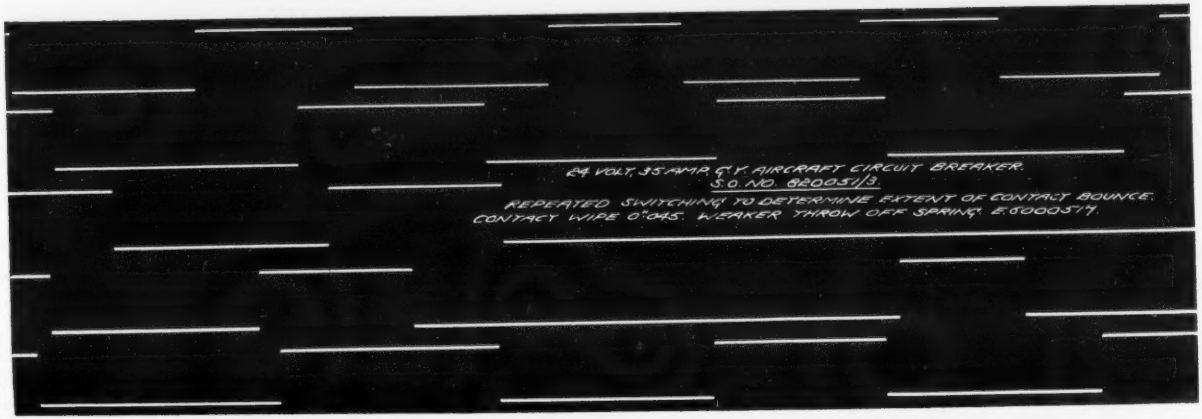

24 VOLT, 35 AMP. G.Y. AIRCRAFT CIRCUIT BREAKER.
S.O. NO. B80051/3.
REPEATED SWITCHING TO DETERMINE EXTENT OF CONTACT BOUNCE.
CONTACT WIPE 0·045. BREAKER THROW OFF SPRING. E.80005/7.

Fig. 5 (b)

Fig. 5 (b)

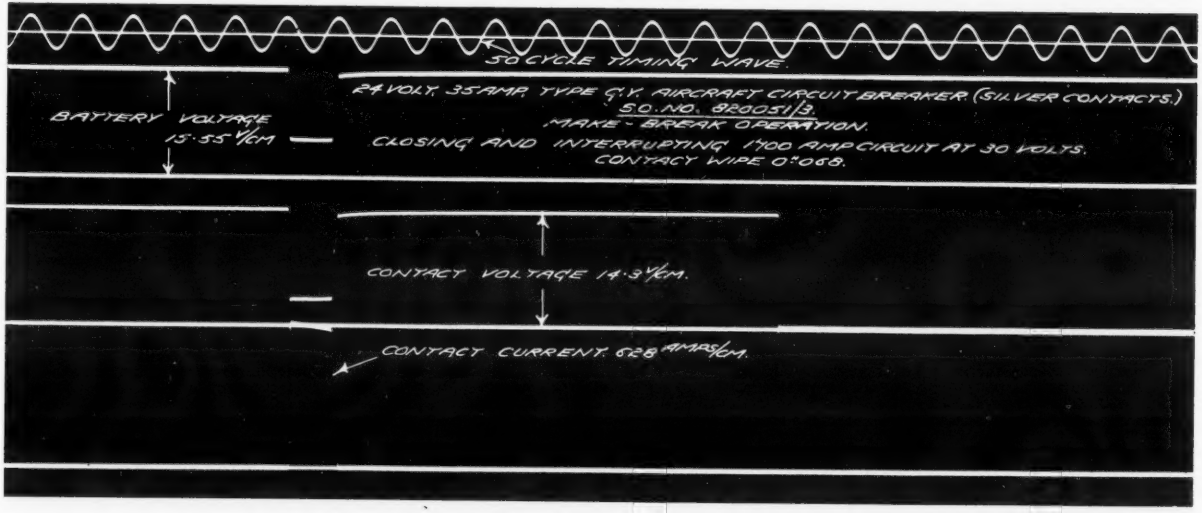

50 CYCLE TIMING WAVE.
24 VOLT, 35 AMP. TYPE G.V. AIRCRAFT CIRCUIT BREAKER (SILVER CONTACTS.)
S.O. NO. 8200318.
MAKE - BREAK OPERATION.
BATTERY VOLTAGE 15·55 V/CM
CLOSING AND INTERRUPTING 1400 AMP CIRCUIT AT 30 VOLTS.
CONTACT WIPE 0·068.
CONTACT VOLTAGE 14·3 V/CM.
CONTACT CURRENT 628 AMPS/CM.

Fig. 5 (c)
Oscillogram, showing successful short circuit test.

advantage to be taken of its low millivolt drop characteristic. For larger units it has been found necessary to employ the higher melting point sintered alloys in order to obtain the desired life and it gradually becomes advantageous to provide pure silver contacts in parallel with alloy contacts, the alloy contacts being arranged with a slight lead to ensure that they perform the making and breaking duty whilst the pure silver contacts provide a low voltage drop when on load.

(*c*) *Considerations on Making-Capacity.*

In addition to choice of contact material it is also of importance to control the closing of the circuit-breaker in order to provide consistent making-capacity. If, on closing, the contacts are allowed to bounce, welding is likely to occur and the risk of this increases very rapidly with peak currents above 1,000 amps. With electrically-closed circuit-breakers, bounce can be readily controlled by keeping the mass of the contact fingers low in relation to the contact loading and by limiting the travel of the contact finger between the positions of contacts first touch and fully closed. In addition, when electrical closing is employed, although the closing speed will vary considerably over the operating range of 16/29 volts normally specified, these speed limits are at least known.

An electrically-operated contact system in which bounce has been satisfactorily controlled is shown in Fig. 2, in which two load carrying contacts are arranged in parallel with an arcing contact provided with a slight lead. In this unit the spring energy, mass and wipe are so proportioned that currents in excess of 4,000 amps can be made repeatedly without welding. Fig. 3 shows a test series on the type D circuit-breaker at 4,500 amps.

For hand-operated circuit-breakers, the closing speed is not known, since it is entirely dependent on the operator. Contact systems directly tied to the circuit-breaker lever or push button are therefore not satisfactory since they can be closed at such a slow rate that arcing at the time of contacts touching may cause welding even without bounce.

A contact system which ensures a constant speed of contact make independent of the operator is shown in Fig. 4, and this unit, weighing $3\frac{3}{4}$ ozs. complete, will satisfactorily make currents over 1,500 amps whatever the speed of operation of the control push button.

The importance of correct speed, inertia, and spring load are shown in Fig. 5 (a), indicating contact bounce on making with the original design. During this test the breaker was fitted with special hard contacts to prevent welding but which would be of too high a resistance for normal use. Fig. 5 (b) shows bounce eliminated after adjustment of the factors mentioned. This film records a number of no load operations specially taken to see if any bounce still remained. Fig. 5 (c) shows the corrected breaker making 1,700 amps without welding, whereas the initial design failed at two-thirds this figure.

(*d*) *Temperature Rise and Selection of Material.*

Specifications for electrical equipment tend to control temperature rise to arbitrary figures. In aircraft it would seem especially desirable to remove such limits other than to specify the extreme working ambients, $-60°$ C. to $+57°$ C. A design should then be accepted as satisfactory on the basis of prolonged operation at maximum load and maximum ambient to determine whether deterioration occurs. Full use could then be made of high grade materials which can safely withstand temperatures above those usually specified and would therefore enable weight to be saved.

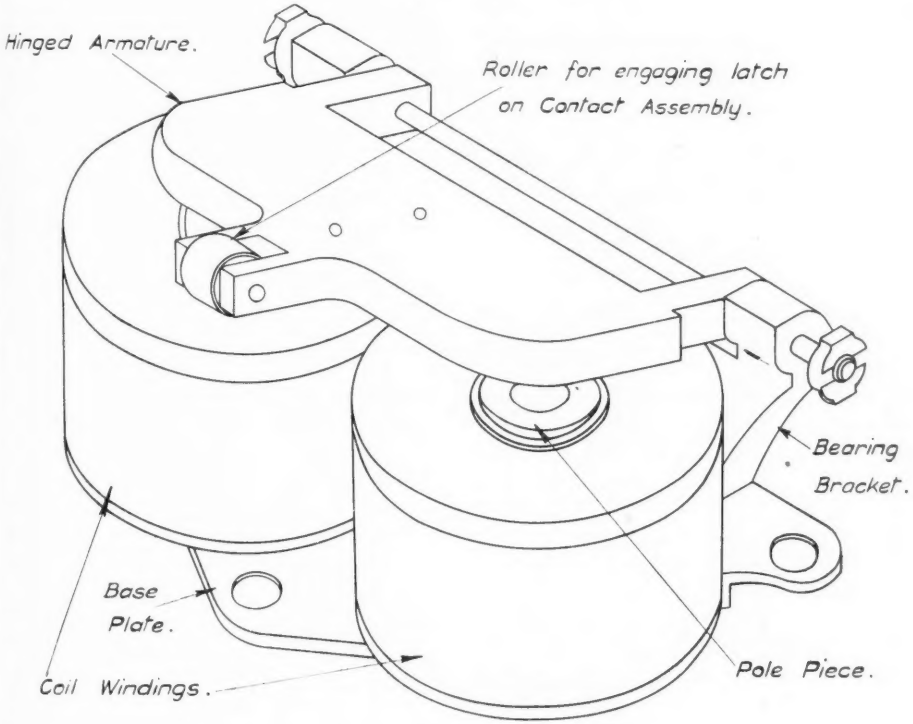
(*e*) *Mechanical Design.*

As airframes may be subject to accelerations of the order of 8g., it is normally specified that circuit-breakers shall withstand accelerations not less than 10g. in the closed or open position. For small panel-mounted circuit-breakers, however, it is found that local accelerations can exceed greatly these

values due to shock on the panel, and it is considered that these units should be able to withstand not less than 50g. The trip gear shown in Fig. 4 is actually stable above 100g.

This circuit-breaker was also subjected to shock tests. The authors feel that the question of aircraft vibration as affecting electrical equipment requires further investigation so that standards may be laid down for such shock tests and mounting in addition to the standard vibration tests at present specified.

In addition to the vibration and operation conditions detailed, units will be required to operate often under no-load or light load conditions. The authors therefore consider that sample units should be subjected to life tests of 50,000 operations to determine that springs, levers and bearings are of adequate design and that adjustments are sufficiently stable. The breakers illustrated will pass such a test.



MAGNETIC CIRCUIT FOR AIRCRAFT CIRCUIT BREAKERS.

Fig. 6

(f) Design of Magnets.

The authors favour the magnet of the hinged type and not the more conventional solenoid type which is considered to be more susceptible to sticking and freezing on its sliding surfaces (see Fig. 6). They also consider that no practical advantage is to be expected at high flux densities of the order of 15,000 lines per sq. cm. from the use of special

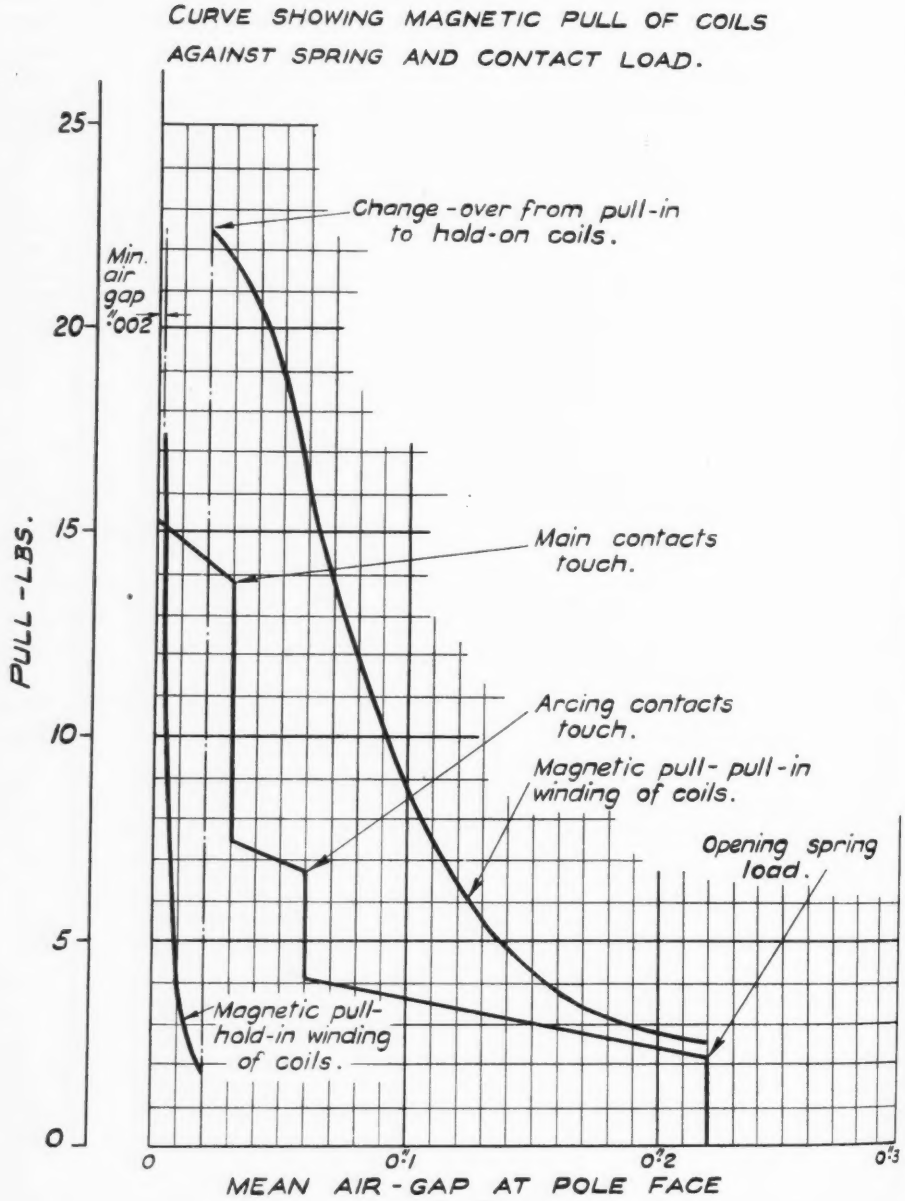


Fig. 7

Magnetic pull and contact load curve for Type D Circuit-Breaker.

steels over ordinary black steel bar which has been annealed.

The determining factors of the magnetic circuits and coils are:—

(i) To ensure satisfactory pull-in at minimum voltage from the initial air gap; and

(ii) To hold in the breaker against the contact loading at minimum voltage and yet not overheat when the maximum voltage is applied to the coil circuits.

It has therefore been found economical to use a double winding coil providing high ampere turns with high pull-in strength and to cut in automatically a high resistance winding reducing the ampere turns for hold-in purposes towards the fully closed position.

An analysis of the electro-magnetic conditions of the magnetic circuit at present used, Fig. 7, shows the effect of these two factors.

The pull required in the closed position is determined almost entirely by the contact load and the coils must be of sufficient capacity to provide this pull at minimum volts. In the open position, it will be seen that the pull required is only a small fraction of the final load being only that necessary to overcome the springs whose purpose is to open and keep open the breaker against accelerations up to 10g. This second requirement can be reduced by balancing the armature and contact system but it is not possible to go very far in this direction as the springs must still be strong enough to provide rapid opening and to bias against torques produced by angular acceleration of the aircraft.

On the magnetic circuit shown, 0.002" air gap exists at each pole piece in the closed position and under this condition 87% of the total flux passes through the pole piece and practically the full flux through the centre of the armature, indicating the efficient use of the iron circuit which is almost saturated under these conditions.

In the open position only 33% of the total flux passes through the pole pieces and 90% of the ampere turns is required to overcome the reluctance of the air gap, but this inefficiency is not of great importance. This is because the closing operation only occupies .025 secs., so that the pull-in winding may be very short time rated, the maximum current which can be used for this purpose being determined principally by the capacity of the auxiliary switch to insert the economy winding and by voltage drop likely to occur in the cables supplying the coil circuit.

(*g*) *Design of Thermal Elements.*

The current time tripping characteristic of the circuit-breaker requires to be as similar as possible to that of the apparatus being protected. For most apparatus this characteristic is closely associated with the current flowing so that the circuit-breaker can be designed to afford adequate protection if the thermal properties of its tripping element are similar to those of the protected apparatus.

Another consideration affecting the protection required is the variation of the current time characteristic with variation in local ambient temperature. If the circuit-breaker is located in a similar ambient to the component protected it should possess the same response to external temperature and would then afford complete protection. If, however, the breaker and apparatus are widely separated as regards ambient conditions, it is not possible for the protection to be so accurate. It is, however, practicable in some instances to improve the protection afforded by compensating the circuit-breaker for ambient conditions.

To obtain equal response to ambient conditions the tripping temperature of the breaker thermal element should be of the same order as the maximum permissible temperature of the apparatus protected. In practice, however, this relationship is not critical and the thermal element is generally arranged to operate at a higher temperature in order to improve breaker consistency by providing more power in the element.

Typical tripping characteristics for a circuit-breaker fitted with a thermal element are shown in Fig. 8. Such characteristics have been found to be satisfactory for the majority

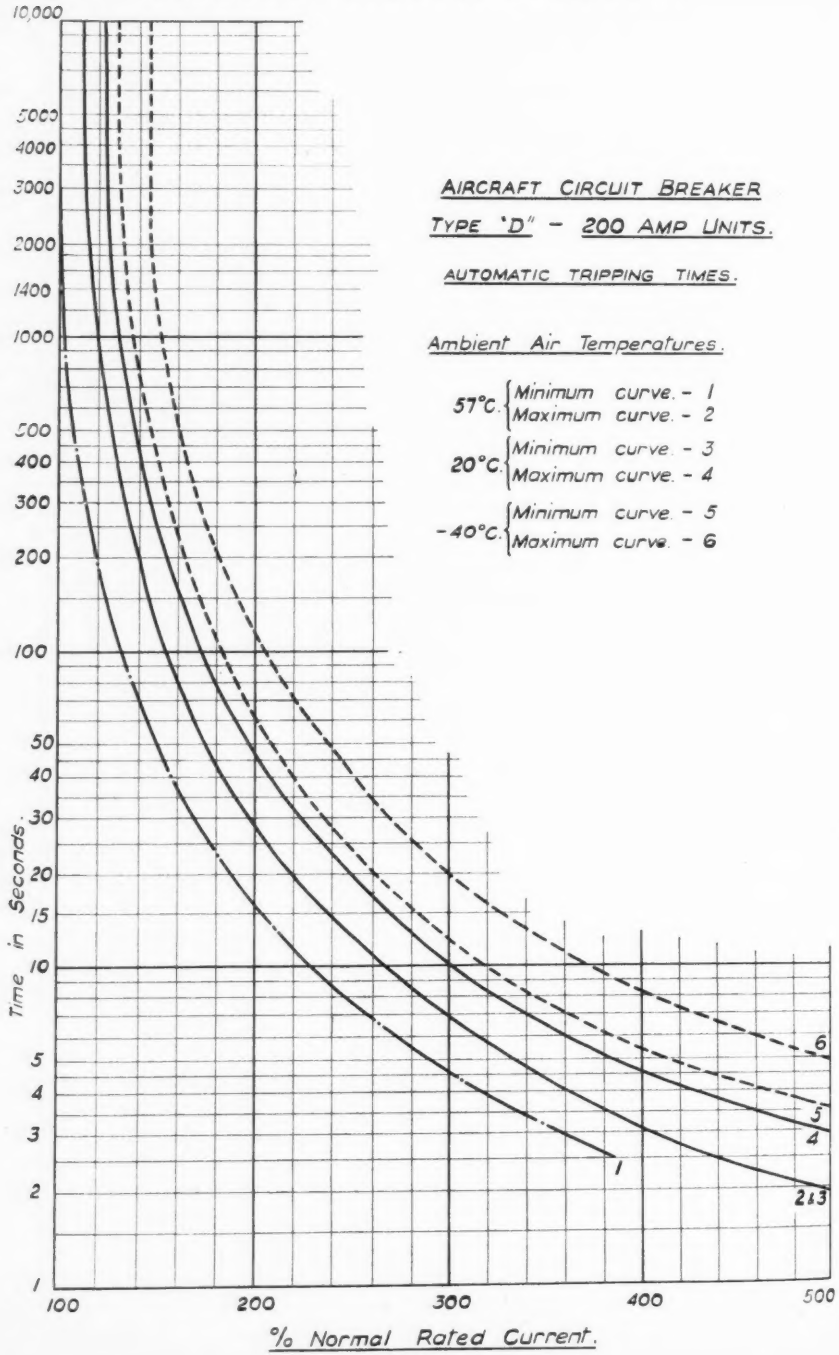


Fig. 8
Characteristic Automtic Tripping curve for Type D Circuit-Breaker

of applications that have so far been considered; these curves show an average correction of 1% in minimum tripping current for a 3° C. change in ambient temperature and this in general is found to allow reasonable protection of associated apparatus even where the ambient condition of the two are different.

The heat generated in the thermal element is generally a fairly large proportion of the total developed in the circuit-breaker and it is important that the watts dissipated in the element should be converted as efficiently as possible into tripping power. This means that the temperature gradient in the element should be as steep as possible at the fixed end and the temperature can with advantage be allowed to decrease towards the operating end.

In the types of breaker so far manufactured the thermal element is arranged to trip the mechanism mechanically and it has therefore to provide adequate strength to overcome the trip load and sufficient deflection to ensure freedom from inadvertent tripping due to vibration and at the same time to make the calibration process reasonably easy. On these units the normal combination is to allow the trip load to be not more than 20% of the force available in the thermal element which will thus possess 80% of the free deflection when tripping the circuit-breaker.

It is essential, however, to relieve all stresses in the thermal element prior to setting, otherwise subsequent variations will occur. This can be done by heat treatment before assembly or by overload operations before calibration. The consistency of the above design is sufficient to allow a trip setting of 125% normal full load current. The range of tripping times at varying temperatures and currents are shown on Fig. 8.

Where greater precision in trip setting is essential the load on the element must be still further reduced and this can best be achieved by introducing electrical relay operation between the element and the circuit-breaker. In such a design the load on the element can be reduced to that required to make a trip circuit only, but the resultant complication is not justified for general application where precision protection is not required or expected.

The authors wish to thank Mr. J. A. Juhlin, Director, Metropolitan-Vickers Electrical Co. Ltd., for permission to publish this paper.

CORRESPONDENCE

c/o The Shell Co. of N.Z. Ltd.,
P.O. Box 1663, Wellington, N.Z.
6th July, 1945.
Received October, 1945.

To the Editor.

Dear Sir,

I have just received the April Journal and read with very great interest the outstanding paper of Air Commodore Banks on the Importance of Power Unit Development and the valuable discussion included in this issue. Being at this distance virtually completely ignorant of the most recent developments it would be presumptuous to hope to contribute new material to this discussion, but my very ignorance prompts me to raise one or two small questions in your pages.

On page 173 of the paper mention is made of the necessity to avoid in the gas turbine the ingress of sand and foreign bodies. From my understanding of the gas turbine problem it would seem that aerodynamic losses in the turbine and blower unit have a vital influence on the overall efficiency and output. In view of this is the air filtration problem, with its presumably inevitable attendant aerodynamic losses, likely to be a serious obstacle to operation of these units in very dusty areas such as deserts.

The maximum temperature allowable in the gas turbine is limited by the blade materials and Dr. Ricardo mentions that the limit to be expected is around 1,000°C. absolute, i.e., 1,800°F. absolute. I believe that exhaust turbines driving supercharges are already operating at this temperature, whereas, as far as I am aware, the highest temperatures used in steam turbines is about 1,000°F., i.e., 1,464°F. absolute.

These figures may not now be correct in relation to each other, but as the steam turbine is normally expected to run tens of thousands of hours without attention instead of periods of the order of 1,000 hours for the gas turbine it would be of interest to know if the problems of high temperature scaling, corrosion, embrittlement and creep are overcome in the gas turbine at the expense of a very much shorter life. At first sight the corrosion and scaling would seem to be much less in the steam turbine than in the gas unit where oxygen is present.

On page 174 of the paper it is stated that high combustion efficiency is necessary and that therefore there are limits to the suitability of the fuel, and Mr. Bass on page 194 of his contribution mentions that the advantage of range of fuel suitability is with the gas turbine. In this connection some recent experience with some Velox boilers is of interest. These units incorporate gas turbines to drive the blowers supplying all the air at approx. 35 lbs./in.^{2} to the main combustion chamber and the outlet gases enter the gas turbine at a maximum temperature of 1,000°F., i.e., 1,464°F. absolute. In these units an indication that efficient combustion was affected by certain types of fuels was given by difficulty sometimes experienced in keeping the turbine gas inlet temperature below the specified figure without reducing the boiler output unduly. The range of fuel which gave satisfactory running extended from the heaviest type of boiler fuel down to light Diesel oils and is therefore at least as wide as could be accommodated without difficulty in the ordinary type of oil fired boiler. Some limits of fuel therefore undoubtedly exist, quite apart from the question of low freezing point and high calorific value required for aircraft fuels. In the case of the boilers mentioned above it must be remembered that no mechanical adjustments such as nozzle shapes and sizes, etc., were made and it would be expected that such adjustments (as with the high speed compression ignition

engine) would allow the use of a very much wider range of fuels. Once the necessary mechanical settings have been obtained for one particular unit, of course, the range of suitable fuels would naturally be more restricted.

The practical side of the actual operation of these turbine and jet propulsion units is, of course, quite unknown to me, but presumably in the initial start up some provision for starting the turbine and blower must be made. Possibly this is done by compressed air, but it would be of great interest to have some information on the actual operating technique. This point reminds me that the propaganda aspect of England's achievements in this field appears to be very much neglected. Apart from the initial announcement of Air Commodore Whittle's work, now well over twelve months ago, and one or two very bare references to jet propelled fighters being used against the V1 flying bomb, the only references that I have seen out here, either in the daily press or in the semi-technical papers, has been to American machines or else the German V1 and V2 units. Possibly now that hostilities have ended in Europe some more details will be given, but bearing in mind the competitive times that British aviation is now facing I cannot but feel that the necessity for some propaganda depicting the British technical achievements in this field is very much overdue. Both in the daily papers and in the semi-technical press pictures have been shown of the American jet propelled aircraft and surely by now something comparable produced in Britain can be published.

T. T. N. COLERIDGE (Associate Fellow).

REVIEWS

A Bibliograph of Visual Literature, 1939-1944.

J. F. Fulton, P. M. Noff and H. T. Perkins. Committee on Medical Research, Office of Scientific Research and Development, Washington, D.C. 1945. Price not stated.

This is Publication No. 11 of the Historical Library of the Yale Medical Library and was initially put in hand at the request of the British Air Ministry. Its general compilation follows that of the excellent Bibliography of Aviation Medicine which was also prepared by Yale University.

The ultimate importance of vision in flying will not be grealy lessened by any aids to blind flying. Such aids are for use in very special circumstances for the expert. The normal pilot will, at all times, have to rely upon his eyes.

The Literature of Vision has grown as rapidly during the war period as has the realisation of the importance of its study from a military point of view. It was early realised, for example, that night flying, night operations by troops, had the effect of the black-out on whole nations, presented special problems of sight.

There are some ninety entries in the Bibliography alone which deal with the effect of vitamins, or their lack, on vision, and eighty entries on the effect on Vitamin A on night blindness.

A section of the Bibliography deals with the testing of vision; a section which is not only of great interest to the specialist, but to all those who wish to become pilots as indicating the high standard of not only good eyesight in the general meaning of the term, but of the adaptability of the eye in widely varying conditions of light and visibility.

These Bibliographies prepared under the ægis of the Committee on Medical Research

are for the specialist, but they are none the less valuable because they cover a restricted field. They are certainly Bibliographies which should be on the shelves of the expert.

The Bibliography of Visual Literature is published by C. C. Thomas, of Springfield, Illinois, to whom inquiries should be made.

Theory of Flight.
R. von Mises. McGraw Hill Publishing Co. **36/-.**

There is a fashion much in favour amongst aeronautical writers to include in their preface a note on the class of reader for whom the book is written. Very often it would appear that the author made the decision as to which class he has written for after he had written the entire book. This practice leads to books which do not fulfil their purpose, with sections for the expert and the beginner jostling each other through the text.

Mr. von Mises has obviously written his preface first or, at least, clearly defined his intention before embarking on the book. He has written primarily for the person who has a solid grounding in the fundamentals while not sufficiently equipped in high mathematics to obtain his knowledge from research papers. The book is well written and is remarkably consistent, the subject being dealt with in a uniform manner, building up the readers knowledge thoroughly and rapidly. The book is essentially one to study from, it is no list of ready made formulæ.

The sections covered are Equilibrium and Steady Flow in the Atmosphere—in which Reynolds number is explained more clearly than in many larger volumes, the Aeroplane Wing up to the study of elementary compressibility effects and the Propeller and Engine. The last two sections are Aircraft Performance and Control and Stability.

Referring to the preface again the author sets himself the task "to develop interest in and understanding of the ideas that underlie the design and the operation of modern aircraft." He does it.

AN APPRECIATION

The Council of the Royal Aeronautical Society wish to thank the following Companies who, by their generous co-operation, have done so much to help in the production of the Journal in its new form.

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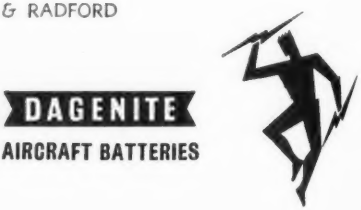

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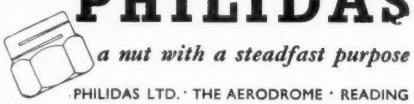

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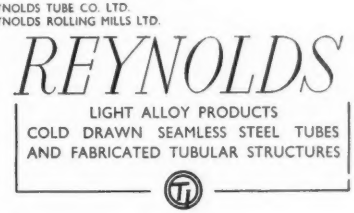

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	49-59 Armley Road, Leeds, 12	*Armley* 38081-5
Messier Aircraft Equipment Limited	Liverpool Road, Warrington	*Warrington* 2244
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Miles Aircraft Limited	Reading, Berkshire	*Reading* 60811
Henry Miller & Company	"Skyhi" Works, Standard Road, Park Royal, London, N.W.10	*Willesden* 1302-3-4
Mollart Engineering Company Ltd.	Kingston By-Pass, Surbiton, Surrey	*Elmbridge* 3352-3-4 (3 *lines*)
The Mond Nickel Company Ltd.	Grosvenor House, Park Lane, London, W.1	*Grosvenor* 4131
Monochrome Limited	Studley Road, Redditch, Worcs.	*Studley* 121-2
Morrisons Engineering Ltd.	Purley Way, Croydon	*Croydon* 0191
D. Napier & Son Limited	Acton, London, W.3	*Shepherds Bush* 1220
Nitralloy Limited	47 Bank Street, Sheffield, 1	*Sheffield* 25907
The Palmer Tyre Ltd.	Herga House, Vincent Square, London, S.W.1	*Victoria* 8323 (6 *lines*)
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Percival Aircraft Limited	Luton Airport, Luton, Beds.	*Luton* 2960
Peto & Radford	Chequers Lane, Dagenham, Essex	*Rainham* 34
Philidas Limited	The Aerodrome, Reading, Berkshire	*Wargrave* 218
Sir Isaac Pitman & Sons Limited	Parker Street, Kingsway, London, W.C.2	*Holborn* 9791 (4 *lines*)
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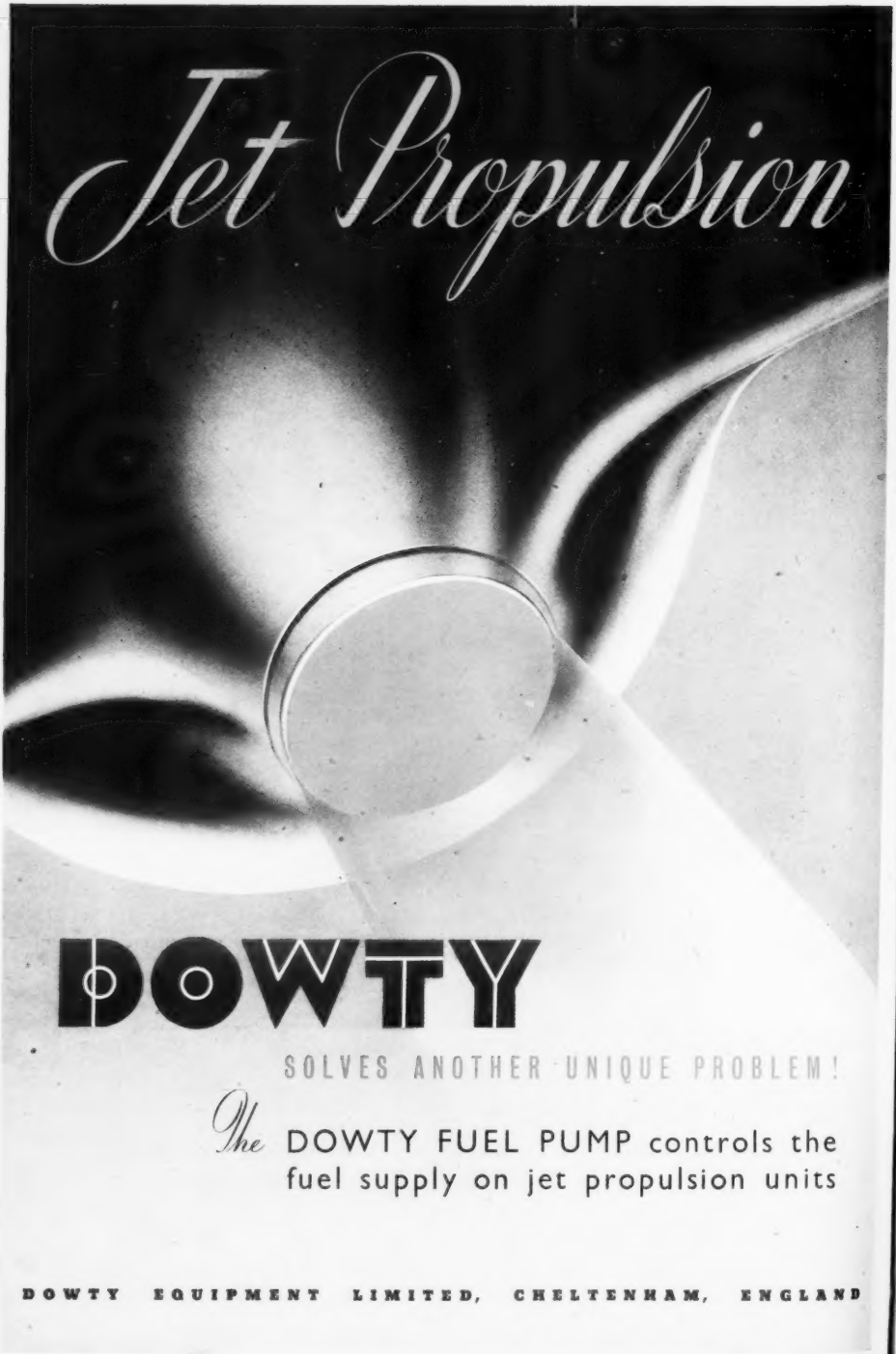
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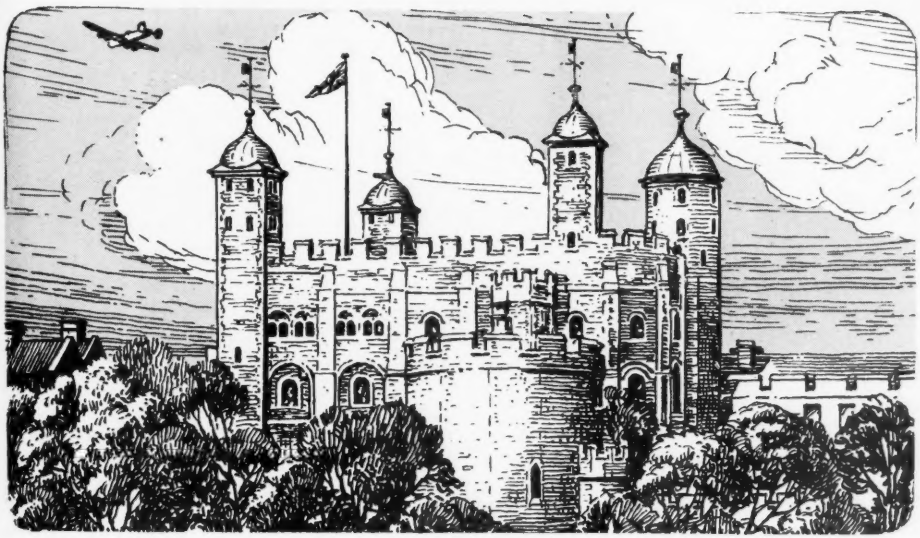

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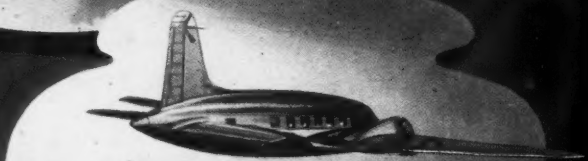

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